# 学 位 論 文 の 要 旨

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| 学　位　論　文　名 | Time Course of Blood Gas Analysis and Application to Inter-Instrument Difference Verification Using Patient Blood Sample as a Control |
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## 論 文 内 容 の 要 旨

### INTRODUCTION

Clinical laboratory technicians in hospital laboratories regularly maintain all testing equipment and return constant test results regardless of the time and person performing the measurement. For this reason, daily quality control is essential. Furthermore, when there are multiple testing devices, it is also required that the results between the measuring devices or reagents be the same. The same applies to blood gas analysis (BGA). Our hospital has a total of 10 blood gas analyzers, and we conduct quality control monthly using control samples.

The end of this study is to investigate whether an actual blood sample can be used as the quality control for BGA instead of control samples. Most errors in laboratory diagnostics fall outside the analytical phase, and BGA may be vulnerable to errors, especially in the pre-analytical phase. On the other hand, patient-based real-time quality control has recently been getting attention, especially in point-of-care testing (POCT). However, at least in our search, no study has been reported to apply actual blood samples to inter-instrument difference verification for BGA.

Therefore, we conducted this study using continuous BGA measurements. Furthermore, based on the results, we attempted to examine the agreement or differences between the two inspection devices to address quality control.

## MATERIALS AND METHODS

The study design was a single-center retrospective observational study. The subjects were patients admitted to our hospital between October 2021 and March 2022 and had blood gas samples taken. The following data collected from medical records was used: date and time of blood sampling, measuring equipment, measurement end time, pH, $pO_2$, $pCO_2$, $HCO_3^-$, $Na^+$, $K^+$, $Cl^-$, $Ca^{2+}$, Glucose, and Lactate. ABL825FLEX (Radiometer Co. Tokyo, Japan) was used as the analyzer, and VP-H050K (Terumo Co. Tokyo, Japan) was used as the vacuum blood collection tube. The room temperature in our facility was monitored all the time and kept at 22-24°C.

1) Continuous BGA measurement: 5 mL of blood was collected into a blood collection tube containing heparin sodium, and measurements were performed 10 times at regular intervals. The measurement interval was approximately 2 minutes and 30 seconds for one analysis. Before each measurement, the sample was mixed by inversion. pH, $pO_2$, $pCO_2$, $Na^+$, $K^+$, $Cl^-$, $Ca^{2+}$, Glucose, and Lactate, were measured and $HCO_3^-$ were calculated from measured $pCO_2$ and $H^+$.

2) Application to inter-instrument difference test: A reference range was calculated from the average value and twice the standard deviation (SD) of the amount of change after 2.5 minutes obtained in the above continuous measurements. Next, using the same sample, we continuously measured in ABL-1 (operating room) and ABL-2 (same equipment as ABL-1) to determine whether there are differences between the devices based on whether or not the data is within the above reference range. The average value and SD of the fluctuations in the measured values of each item were calculated using the spreadsheet software Excel (Office 2019, ©Microsoft).

The study protocol was approved by the Research Ethics Committee of Shimane University. (No. 20220914-3)

## RESULTS AND DISCUSSION

1) Continuous BGA measurement

pH and $pO_2$ increased over time, and $pCO_2$, $HCO_3^-$, $Ca^{2+}$, and glucose decreased over time. That is, during the 2.5 minutes from one measurement to the next, pH increased by an average of 0.028, $pO_2$ increased by 1.7 mmHg, $pCO_2$ decreased by 3.7 mmHg, $HCO_3^-$ decreased by 0.5 mmol/L, and $Ca^{2+}$ decreased by 0.01 mmol/L, glucose showed a decrease of 1 mg/dL. On the other hand, no obvious changes were observed in $Na^+$, $K^+$, $Cl^-$, and Lactate.

The increase in $pO_2$ and decrease in $pCO_2$ over time observed in continuous BGA measurements were thought to be due to contact of the blood sample with the atmosphere.

Generally, $O_2$ is dissolved in the arterial blood of a healthy person at about 70 mmHg to 100 mmHg, and $CO_2$ is dissolved at about 35 to 45 mmHg. In the atmosphere, they are approximately 160 mmHg and zero mmHg, respectively, so if the sample comes into contact with the atmosphere, $PO_2$ will increase over time, $CO_2$ will diffuse into the atmosphere, and $pCO_2$ will decrease. These changes lead to decreased bicarbonate and hydrogen ions through acid-base balance, increasing pH, as shown by the Henderson-Hasselbach equation. As pH increases (alkalosis), binding between calcium and proteins strengthens, and $Ca^{2+}$ concentration is thought to decrease. Glucose was considered to be consumed by glycolysis and decreased over time. On the other hand, no change was observed in the lactate concentration, at least during the observation period.

2) Application to inter-instrument difference test

Using the average value and SD of the amount of change after 2.5 minutes obtained in continuous measurements, the quality control reference range was calculated from the delta values. Next, continuous measurement data for three people were analyzed. The difference of $pCO_2$ and $HCO_3^-$ between the instruments exceeds the above reference range. Based on this result, it was determined that there was a difference between ABL-1 and ABL-2. After the maintenance (extensive washing and cleaning of the $pCO_2$ electrode and membrane replacement), the differences in the other three people became less than the reference range, suggesting a significant improvement.

This study demonstrated that the method can be applied to inter-instrument difference testing using human samples based on the change after continuous measurement. Based on the BGA results from 6 patients before and after the device maintenance, the importance of daily maintenance was realized to guarantee the laboratory data.

## CONCLUSION

This study revealed the time course changes in blood gas measurements in our laboratory. Furthermore, the feasibility of testing differences between blood gas analyzers using patient samples was suggested.